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Global Precipitation and Its Thermodynamic Features with DPR Data

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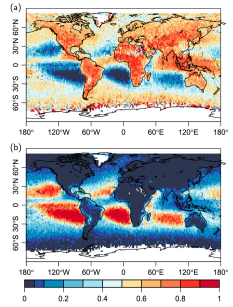
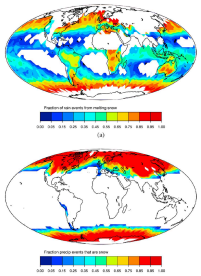
I. INTRODUCTION

Space borne radars have been used to characterize global distribution of precipitation according to its thermodynamic phase. With observations from CloudSat and CALIPSO, Mulmenstadt et al. (2015) studied global climatology of rain frequency from liquid-, mixed-, and ice-phase clouds. Field and Heymsfield (2015) quantified rain events linked to snow melting at a higher altitude.



Mulmenstadt et al. Fig. 1: Fraction of raining clouds that are (a) ice phase, (b) liquid phase (2006-2011)



Field and Heymsfield Fig. 3: DJF fraction of (a) rain events from melting snow, (b) precip. events that are snow. (2008-2010)

The Dual-frequency Precipitation Radar (DPR) on the Global Precipitation Measurement (GPM) core satellite provides high-accuracy three-dimensional observations of precipitation over the globe. We use 3 years of DPR data (from 2014 to 2017) to study occurrence, intensity, and thermodynamic properties of global precipitation systems. The focus of the current study is for Northern Hemisphere winter months, December, January, and February.

II. GPM DPR

The level-3 DPR dual-frequency products from the matched swath (dprMS) with 5 degree grid resolution are used in the investigation.

a. Surface precipitation

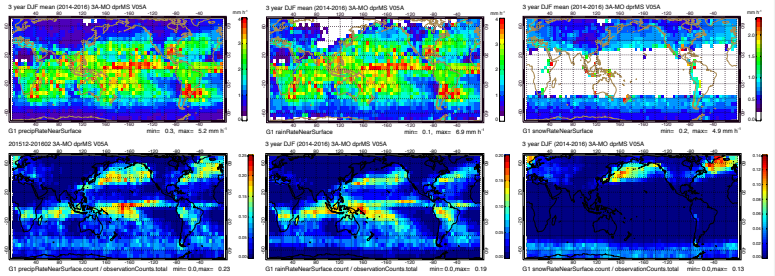


Fig. 1: 3 year DJF mean precipitation (left), rain (mid), snow (right) rates (top) and the corresponding occurrence frequencies (bottom)

- The occurrence of precipitation clearly depicts the oceanic storm tracks in the North Pacific and North Atlantic
- The storm track in N. Atlantic reaches further north than its counter part in N. Pacific
- Most frequent occurrence of snow occurs over oceans
- The Intertropical Convergence Zone (ITCZ) has generally higher precipitation rate
- The maritime warm clouds (as shown in early studies) have low precipitation rate
- Southern Ocean has active storm occurrence
- Surface snow occurrence is similar to Field and Heymsfield (2015).

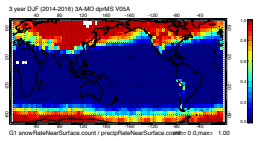
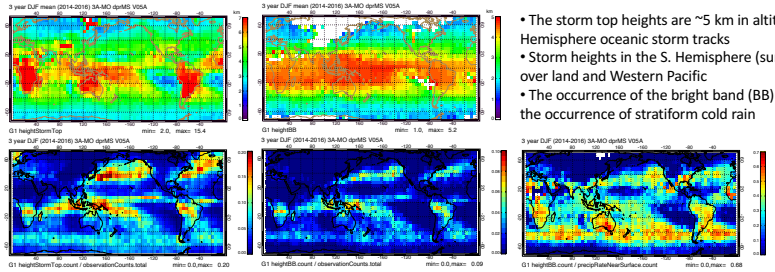


Fig. 2: surface snow occurrence

References:
Mulmenstadt, J., O. Sourdeval, J. Delanoe, and J. Quaas (2015), Frequency of occurrence of rain from liquid-, mixed-and ice-phase clouds derived from A-Train satellite retrievals, Geophys. Res. Lett., 42, doi:10.1002/2015GL064604.
Field, P. R., and A. J. Heymsfield (2015), Importance of snow to global precipitation, Geophys. Res. Lett., 42, 9512–9520, doi:10.1002/2015GL065497.

b. Storm top height and bright band height

The storm top height is determined by the radar echo top height, which is one indicator of storm intensity. The bright band (BB) is detected using the dual frequency ratio method, which is used to classify rain type (stratiform, convective).

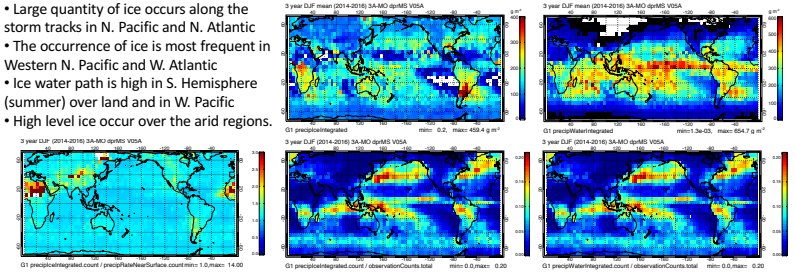


- The storm top heights are ~5 km in altitude in the N. Hemisphere oceanic storm tracks
- Storm heights in the S. Hemisphere (summer) are higher over land and Western Pacific
- The occurrence of the bright band (BB) height indicate the occurrence of stratiform cold rain

Fig. 3: 3 year DJF mean storm top height (left) and bright band height (right) and frequency of occurrence (bottom)

c. Precipitation ice and liquid water path

Fig. 4: 3 year DJF mean precip. ice water path (left 3) and liquid water path (right, color shading from 5 g m^{-2}) and frequency of occurrence (bottom)



- Large quantity of ice occurs along the storm tracks in N. Pacific and N. Atlantic
- The occurrence of ice is most frequent in Western N. Pacific and W. Atlantic
- Ice water path is high in S. Hemisphere (summer) over land and in W. Pacific
- High level ice occur over the arid regions.

d. Mean hydrometeor diameter and precipitation rate at different altitudes

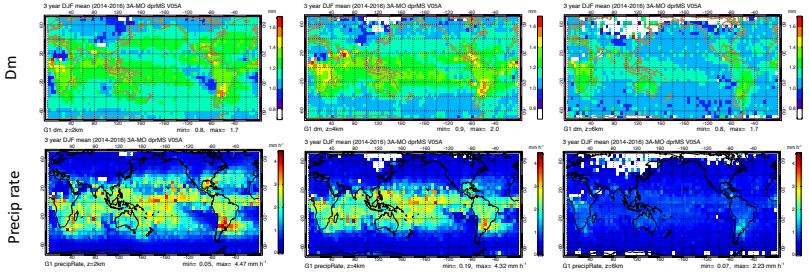


Fig. 5: 3 year DJF mean diameter (Dm, melted) and precip. rate at altitudes of 2, 4, and 6 km.

- Along the N. Pacific and N. Atlantic storm tracks, the Dm is ~ 1.3 mm at 2 km altitude, and decreases at a higher altitude
- In S. Hemisphere, Dm increases from 2 km to 4 km altitude
- The SE Pacific has small Dm at 2 km (may corresponds to stratocumulus cloud), verification needed for Dm at 4km

III. SUMMARY

Three years of GPM DPR data are used to examine the occurrence, intensity, and thermodynamic properties of precipitation during DJF. In this study, analyses show distributions of global precipitation occurrence generally consistent with early studies. The GPM observations provide additional insightful aspects regarding the distribution of snow, ice water path and particle mean sizes. Further investigation may be conducted on specific climate regimes, e.g., the oceanic storm tracks, as well as stratocumulus regions and snow regions at high latitudes.